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Crack Detection Using Low-frequency Ultrasonic Waves Caused by Low Directivity and Scattering

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In recent years, nondestructive testing techniques for maintenance and checking of materials and structures have been more required with social infrastructure's aging. Although ultrasonic waves are valid in internal inspection, conventional ultrasonic detection techniques are inadequate for detecting fatigues or closed cracks, because ultrasound waves hardly reflect at them[1]. However, it has been reported that the transmitted wave through a closed crack contains nonlinear ultrasonic waves[2] such as super- and sub- harmonics, and they have been expected to be used for an alternative detecting method.

In our previous research, we experimentally examined transmission of ultrasonic waves through contact surfaces of two metal blocks stacked and compressed in order to simulate a closed crack as in ref[3]. The experiments showed that an ultrasonic wave transmitted over a contact solid interface consists of not only the transmitted fundamental frequency component but also much lower frequency spectra[4]. The magnitude of the low-frequency component is a function of the incident angle and expected to use for developing a comprehensive method which allows unskilled engineers to detect cracks. In this paper, we focused on angles for developing a new method by low-frequency components. The objective of this paper is investigating characteristics of low frequency spectra for the relative angle between the transmitting and receiving transducer.

We conducted two experiments. The first experiments showed that the ratio of low frequency components changed significantly when the incident angle was near the directivity angle. If there is a crack in a specimen, ultrasonic waves, after scattered at the crack tip, are received from oblique direction. This can cause change in the ratio of low frequency components. In the second experiments, in order to identify the position of the crack tip, we used the dependence of ratio of low frequency components on the incident angle. From the above results, we proposed a new method to identify cracks by using low frequency components and the directivity angle.

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